Inquiry with a Purpose: Linking Data Analysis and Discipline-Based Literacies

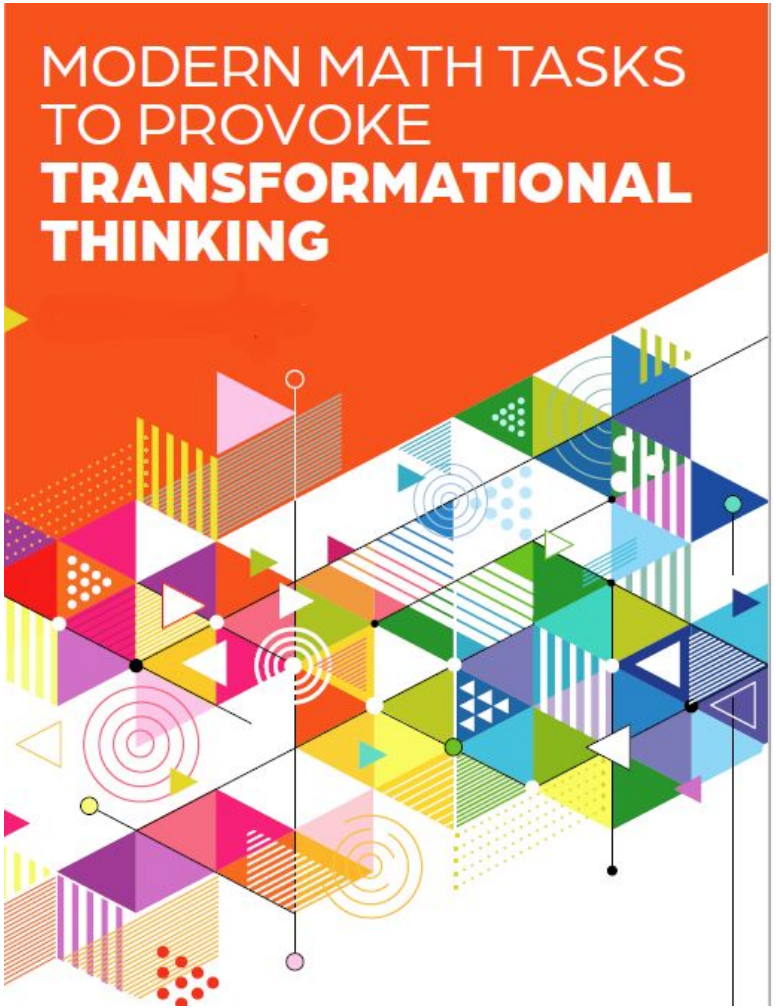
Rick Hudson, University of Southern Indiana
Dionne Cross Francis, University of North Carolina
Andrew Gatza, Ball State University
Jinqing Liu, University of California, Irvine
Charles Wilkes III, San Diego State University

National Council of Teachers of Mathematics Annual Meeting
October 28, 2023

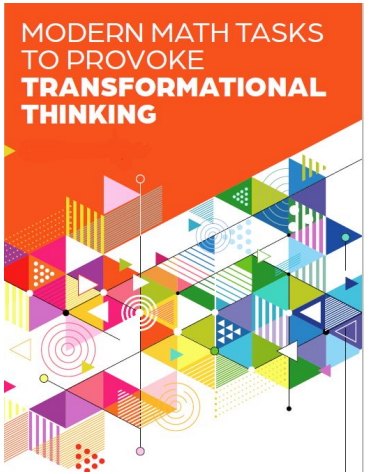
Goals of the Session

- learn about tasks designed to connect mathematics and discipline-based literacies
- engage and reflect on the statistical investigation process
- become familiar with the *Pre K-12 Guidelines for Assessment and Instruction in Statistics Education II* and its implications for grades 3-5 learners

Grades 3-5 Book in Development



Need for the Book Series

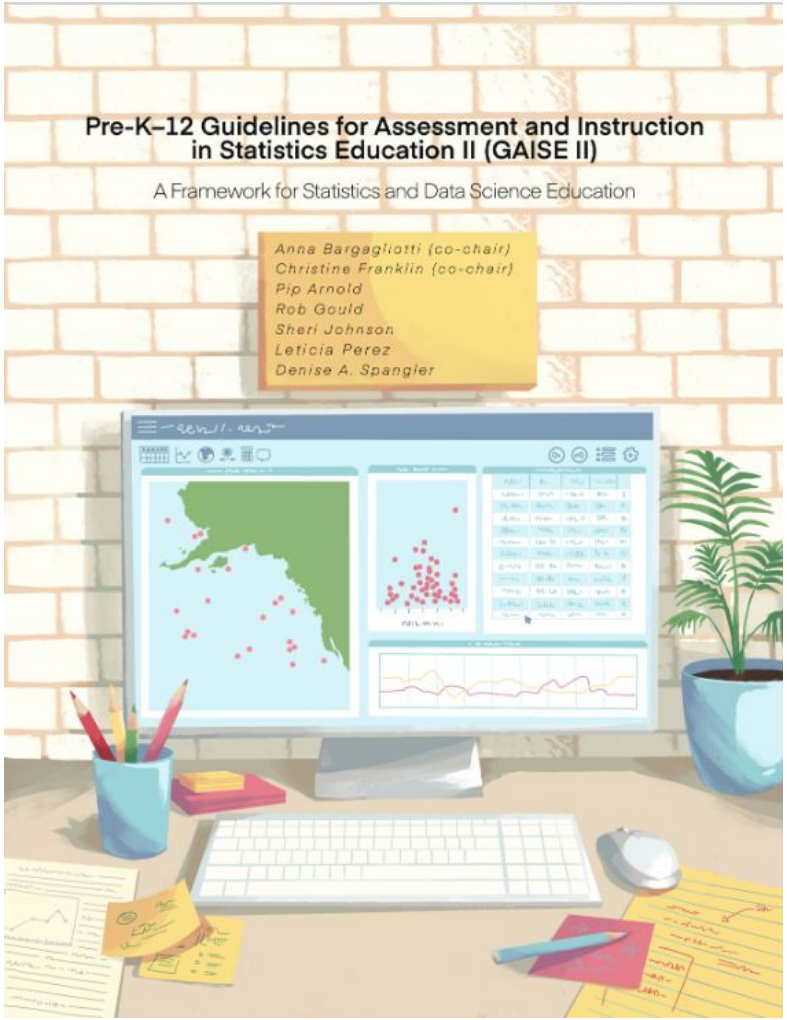


Big problems are interdisciplinary.

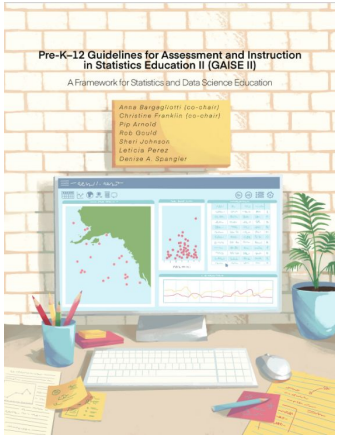
Lessons aren’t (typically).

The tasks in this series are designed to support interdisciplinary, transformational thinking.

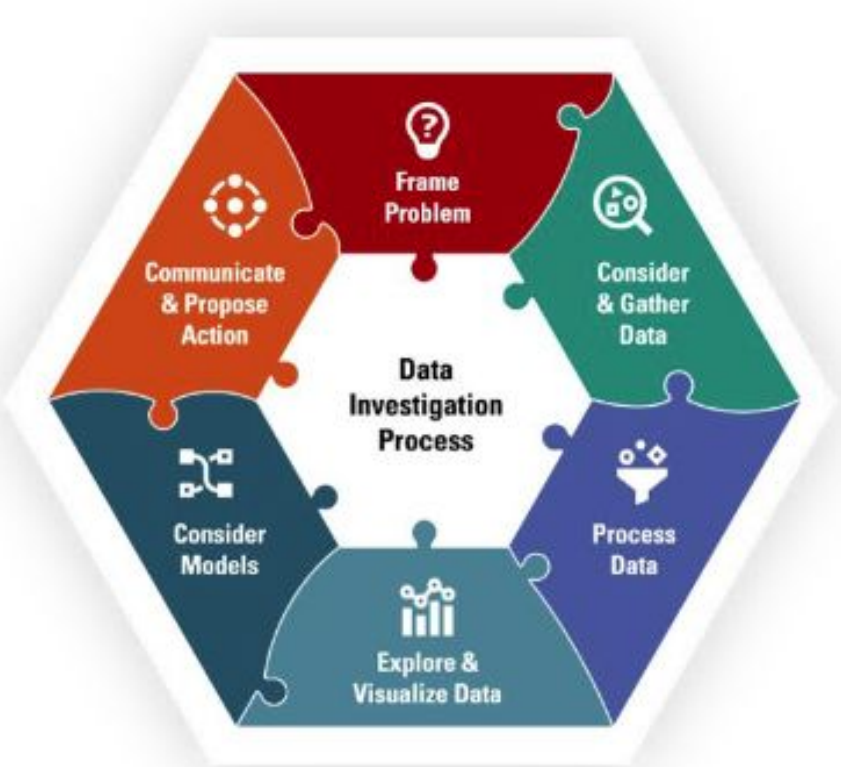
Guidelines for Assessment and Instruction in Data Science and Statistics Education II (GAISE II)



"It is critical that statisticians—or anyone who uses data—be more than just data crunchers. They should be **data problem solvers** who interrogate the data and utilize questioning **throughout the statistical problem-solving process** to make decisions with confidence, understanding that the art of communication with data is essential." – GAISE II



Data Investigation Process



from Lee et al. (2020)

Turn and Talk:
How do your students experience different parts of the process?

Three Data Investigations

- Everyone Counts: Examining Issues of Fairness in Creating Voting Districts
  - Political and Civic literacies
- My Shirt Comes from Where? How Clothes Travel
  - Geographic and Economic literacies
- Life in a Square
  - Ecological literacy

Everyone Counts: Examining Issues of Fairness in Creating Voting Districts

Interdisciplinary Connections

Civic literacy involves developing a set of skills that members of a community can draw upon when they consider how to effectively participate in their communities.

Beyond participating in a formal government, **civic literacies involve all of the practices of doing democracy,** including deliberation, fact-finding, valuing civility, seeking harmony, working for justice, informed decision making, and others (e.g., volunteering, jury duty, **voting**, and other participatory forms of acting for the betterment of society).

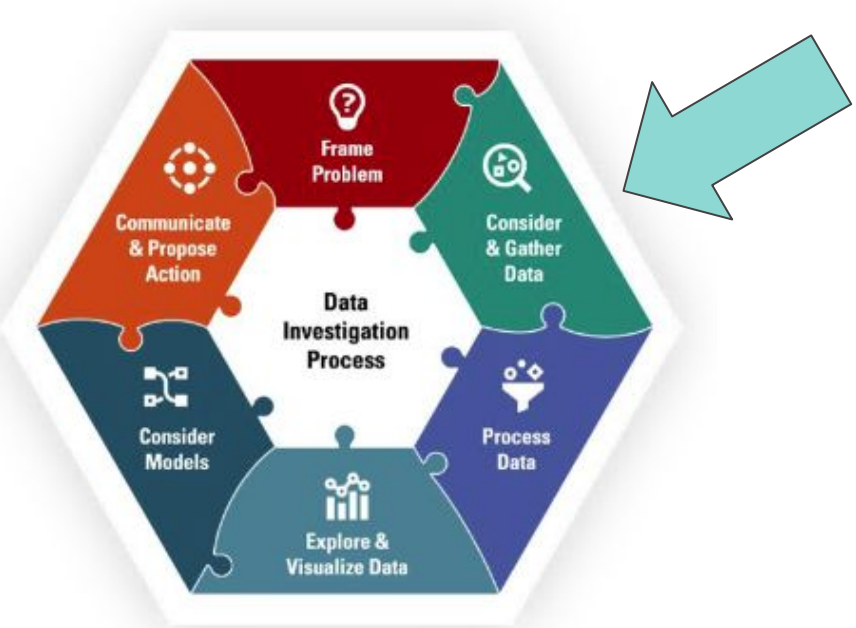
Political literacy requires a skillset that understands **how levels of government interact**, how they **change** over time, and where **citizens can effect change**.

Practicing skills of **deliberation**, **informed decision making**, and **taking informed action** are all inherent to the core of both political and civic literacies.

How can mathematics be used to develop political and civic literacy?

- Issues of **voting** occur all around us, but **how do we decide what is fair?**
- The **mathematics of voting can be quite complex**, with no easy or clear answer for what is fair.
- This lesson explores issues of **voting**, **representation**, and **fairness** in the democratic process.

Who has the final say?



- This activity uses **data collection and displays** to **explore the meaning of fairness** in a classroom vote on an issue of importance to the class, starting with one vote per one person.

- After data from a **simple majority** situation is collected and analyzed, students then **investigate alternate voting scenarios** in relation to the initial one-to-one voting case.

What is *fair* and how can we understand *fairness*?

- The Case of **Victoria Woodhull**
  - After a careful read of the constitution, she discovered that nothing prohibited her from running for president.
  - In 1870, she was the first woman to run for president …even though she couldn't even vote for herself!

What makes voting fair?

Voting and Representation Exploration

- Select a meaningful topic for your class on which they can vote and create bar graphs to represent results.

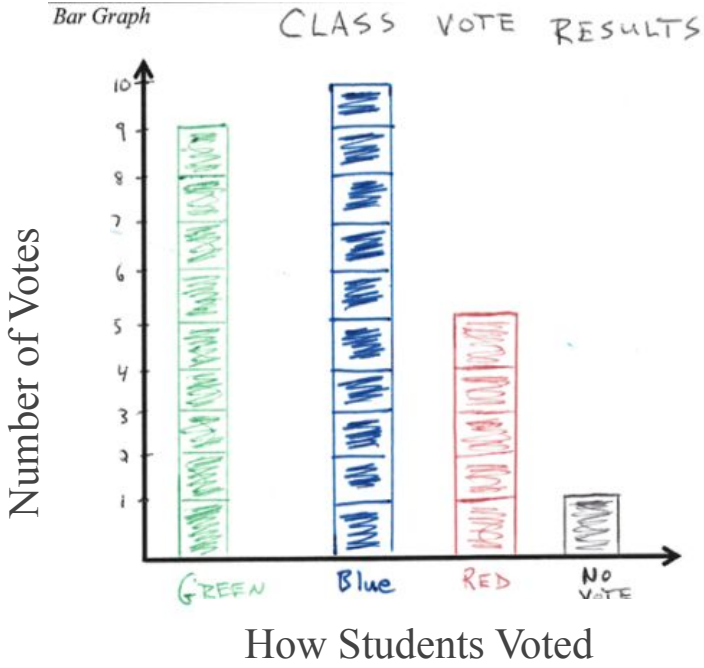
- To create wider variation in data displays, select a topic with three choices (e.g., different read aloud books, possible uniform options, etc.) AND a topic where everyone is not likely to vote the same way.

- Alternatively, simulate a vote by randomly distributing a set of cards to the class that indicate the option they should support (e.g., color preference).

Voting Round #1:
1 Student, 1 Vote: Color Preference

Discuss results by interpreting the bar graph:

- What do you notice about the bar graph?
- How can bar graphs help make sense of data?
- How many more votes did the top category receive than the next closest category?
- How many fewer votes did the lowest category receive as compared to the winning category?



1 Sticky Note = 1 Student

Voting Round #1:
1 Student, 1 Vote: Color Preference

- Create a **set model representation** to indicate fraction of the class within each category.
  - number of students who voted for a particular category is the numerator
  - number of students in the class is the denominator

Voting Round #2:
1 Student, 1 Vote. Restriction: Color Preference

- Recall the case of **Victoria Woodhull**. Women were not allowed to vote in 1870.
- Re-do the vote from Voting Round 1, again using sticky notes, except now **only half the class can vote** (e.g., left half of classroom).

Turn & Talk

- How might this bar graph compare to the bar graph created in the first round of voting? Where might you see similarities and differences in the representations?
- How might these mathematical conversations drive conversations of fairness?

Voting Round #3:
1 Small Group, 1 Vote: Color Preference

- Form small groups of equal size (representative rather than direct democracy).
- Re-do the vote from Round 1, except each small group now only gets a single vote (not each student).

1 Sticky Note = 3 Students

Turn & Talk

- How might this bar graph compare to the previous two bar graphs? Where might you see similarities and differences in the representations?
- How might these mathematical conversations drive conversations of fairness?

Voting and Representation Exploration

- **Voting Round #1:** One person, one vote.
- **Voting Round #2:** Re-do the vote from Round 1, except now only half the class can vote (e.g., left half of classroom). Compare results.
- **Voting Round #3:** Form small groups of equal size. Re-do the vote from Round 1, except each small group now only gets a single vote. Creates **scaled bar graph** and begins to highlight importance of “group” creation process in a representative (rather than direct) democracy.

Discussion Questions for Students

- What did you notice about the bar graphs for each round of voting? What did one sticky note represent in Round 3 and how did this compare to the previous rounds?
- What similarities did the bar graph and set model representations show us?
- Were the results of each round of voting the same? Why do you think this happened?
- With regard to the set model representations, what similarities and differences do you notice across each round of voting? Did the size of the class change?
- **How accurately did the voting process of each round reflect the preferences of the whole class? How do you know?**

Summary

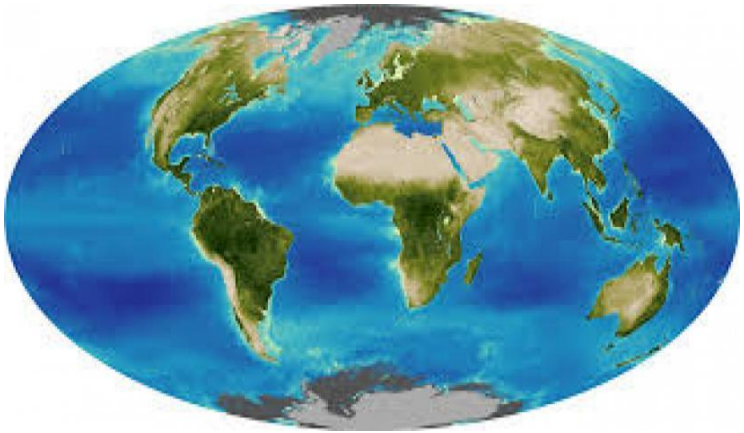
- This task uses **data collection and displays to explore the meaning of fairness in a classroom vote** through the investigation of different voting scenarios.
- Students **construct** and **analyze** different **bar graphs** and **set model fractional representations** to compare and contrast relative fairness, as determined by the class, across situations.
- Students **identify the impact of changes** in the voting process and **use mathematics to support arguments about representation** and **fairness** in decision making.

My Shirt Comes from Where? How Clothes Travel.

Interdisciplinary Connections

Geographic literacy: As students consider how people in different parts of the world have all participated in the economic process of production, they begin to understand human-environment interaction, location, and movement.

Economic literacy: Students learn about production and consumption, understood contextually through the example of garments and the resources used to make them.



Think about It...

Do you know where your clothes came from?

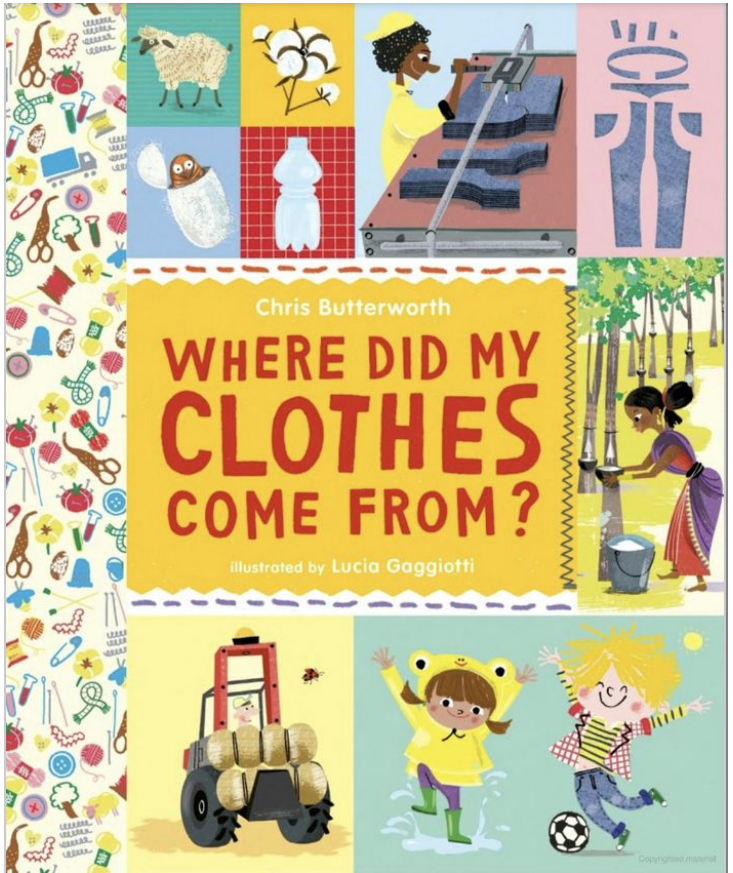
How far did they travel before you first put them on?

What are they made of?

Who was involved in making them?

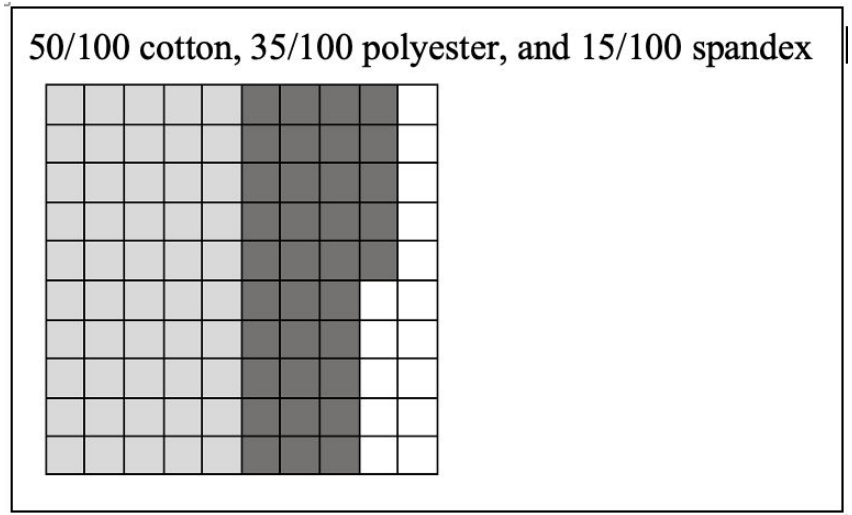
Starting this Unit…

- Read the book *Where Did My Clothes Come From?* (or watch here: https://www.youtube.com/watch?v=HbKoXpmAmCo)



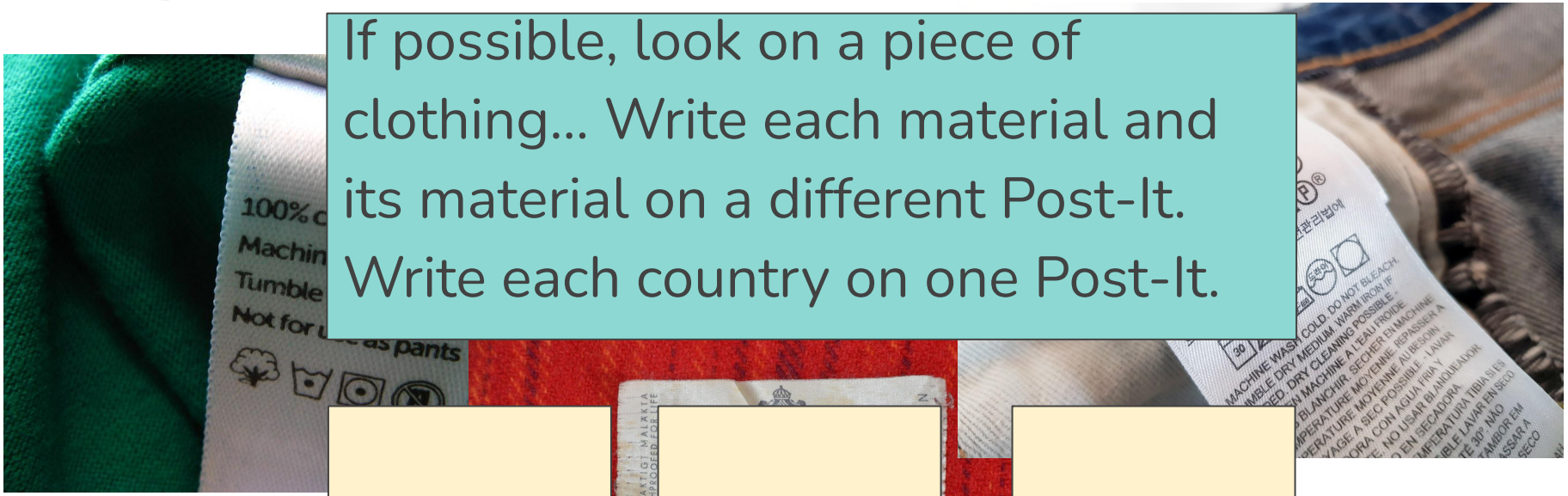
Starting this Unit...

- Initial investigation can focus on the meaning of percent and making representations to model



What data is shared on clothes tags?

If possible, look on a piece of clothing... Write each material and its material on a different Post-It. Write each country on one Post-It.



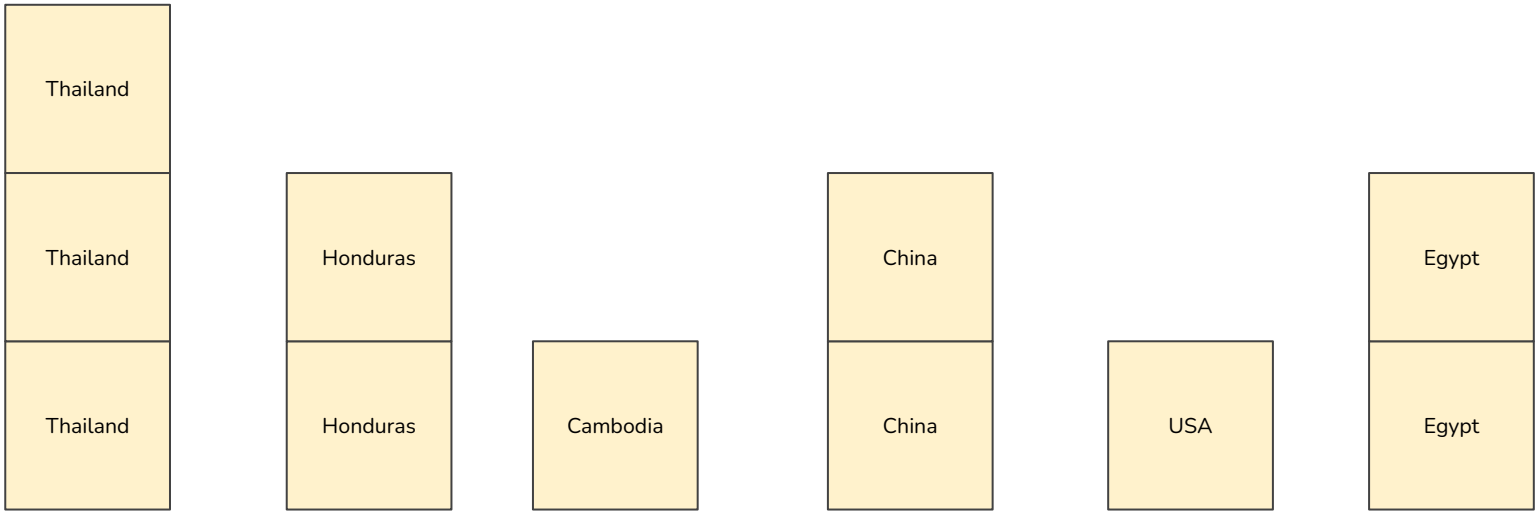
Cotton
25%

Polyester
75%

Thailand

Create a data visualization

Add your post-it notes to the graphs on the wall. Group similar results together.



Importance of Data Collection

Students are part of the process, so they understand the data.

Different ways to access data

- Bring in some clothes to collect in class
- Assign students to look at home

Data collection can involve collecting Post-It notes, however you can also use Google Forms or other technology to collect data.

Thinking about Data Processing

Processing data means how we turn collected data into usable information. This may require recoding or further classifying the data.

What do you notice about the data?

1	Type of Clothes	Made	HowManyMaterials	PercentCotton	PercentPolyeste	PercentSpandex	PercentNylon	PercentLyocell
65	Jacket	India	1					100
66	Shirt	Romania	two	60	40			
67	Sweater	Vietnam	two	80	20			
68	Sweater	Jordan	one		100			
69	Flannel	Bangladesh	one	100				
70	Pants	China	one		100			
71	Pants	Indonesia	2		8			
72	Shorts	Veitnam	3			4		
73	Shirt	Honduras	1	100				
74	Leggings	Jordan	2		75			
75	Pants	Cambodia	3		47.5	5		
76	Shorts	Vietnam	1		100			
77	tshirt	USA	1	100				
78	sweater	China		50	50			
79	shirt	India	2	50	50			
80	jeans	Mexico	3	92	7		1	

Data Cleaning

Sweater vs. sweater

1 vs. One

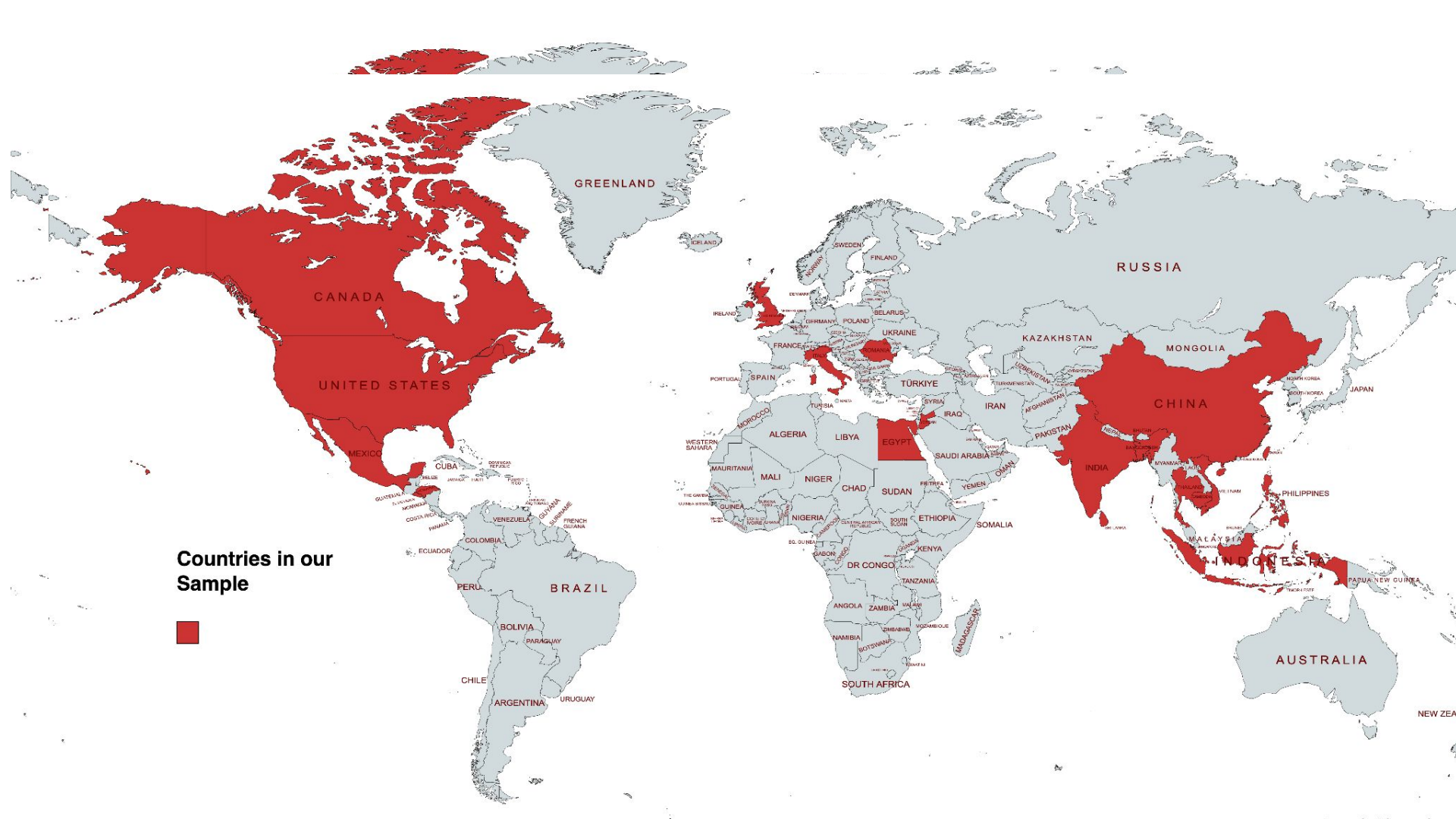
T-shirt vs. tshirt vs. T-Shirt

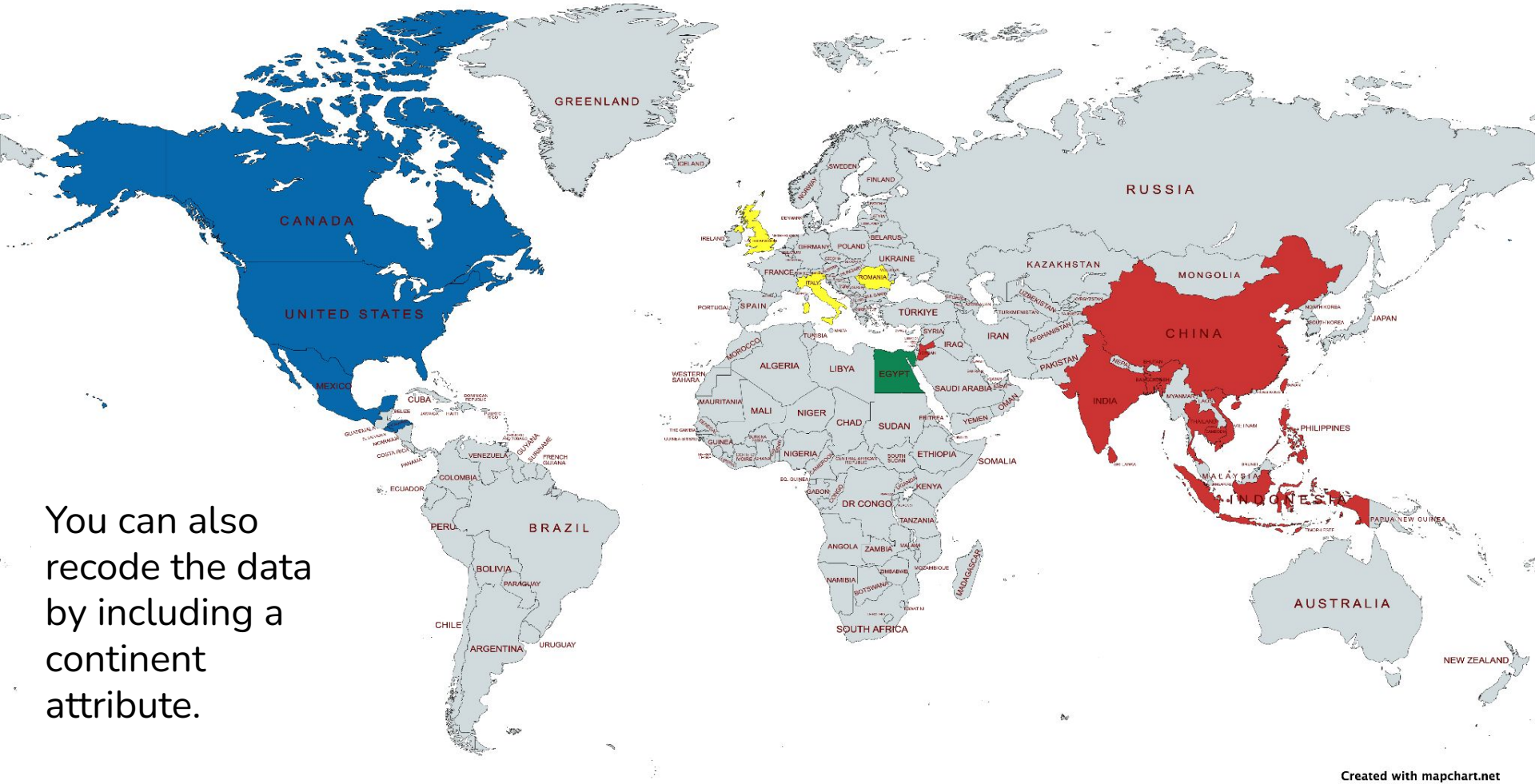
Vietnam vs. Veitnam

Dealing with Missing Data


Initial Data
Crewneck
Vest
Hoodie
T-Shirt
Flannel
Jeans
Blouse
Tanktop
Romper
Shorts
Jean Jacket
Sweatpants
Pants
Sweatshirt
Khakis
Skirt
Dress
Tie
Dress Shirt
Sweater
Jacket
Polo
Coat
Leggings
Denim Shorts
Button Up Shirt

Data Recoding

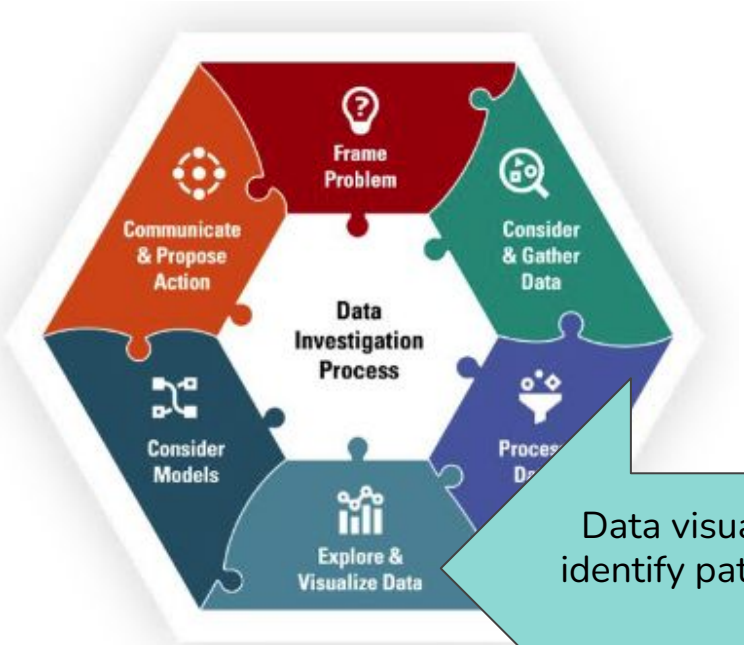

Countries in our Sample
GREENLAND
CANADA
UNITED STATES
MEXICO
CUBA
BELIZE
GUATEMALA
HONDURAS
EL SALVADOR
NICARAGUA
COSTA RICA
PANAMA
VENEZUELA
GUYANA
SURINAME
FRENCH GUIANA
COLOMBIA
ECUADOR
PERU
BRAZIL
BOLIVIA
PARAGUAY
CHILE
ARGENTINA
URUGUAY
ICELAND
NORWAY
SWEDEN
FINLAND
RUSSIA
IRELAND
DENMARK
ESTONIA
LATVIA
LITHUANIA
BELARUS
GERMANY
POLAND
UKRAINE
FRANCE
SLOVAKIA
HUNGARY
ROMANIA
MOLDOVA
PORTUGAL
SPAIN
ANDORRA
SLOVENIA
CROATIA
BOSNIA AND HERZEGOVINA
SERBIA
MONTENEGRO
ALBANIA
GREECE
TÜRKIYE
KAZAKHSTAN
MONGOLIA
UZBEKISTAN
TURKMENISTAN
KYRGYZSTAN
NORTH KOREA
SOUTH KOREA
JAPAN
CHINA
TUNISIA
SYRIA
IRAQ
IRAN
AFGHANISTAN
PAKISTAN
NEPAL
BHUTAN
BANGLADESH
MYANMAR
MOROCCO
WESTERN SAHARA
ALGERIA
LIBYA
EGYPT
SAUDI ARABIA
OMAN
INDIA
MAURITANIA
MALI
NIGER
CHAD
SUDAN
ERITREA
YEMEN
PHILIPPINES
GUINEA
BRUNEI
VIETNAM
NIGERIA
CAMEROON
CENTRAL AFRICAN REPUBLIC
SOUTH SUDAN
ETHIOPIA
SOMALIA
MALAYSIA
EQ. GUINEA
GABON
CONGO
KENYA
INDONESIA
DR CONGO
TANZANIA
PAPUA NEW GUINEA
ANGOLA
ZAMBIA
MALAWI
MOZAMBIQUE
ZIMBABWE
NAMIBIA
BOTSWANA
MADAGASCAR
SOUTH AFRICA
AUSTRALIA
NEW ZEA



You can also recode the data by including a continent attribute.

Created with mapchart.net

Thinking about Data Visualization



Data visualizations help students to identify patterns and reason about the context.

What could our data look like?

CODAP Investigation: https://bit.ly/NCTMClothes23

Investigate dragging different variables to the axes or to the center of the graph. Write a statement to interpret the graph(s) that you create.

What are you finding?

Think beyond the data. Why do you think you found what you did?

Digging Deeper… Distance traveled

Clothing Item Place of Production	Clothing Item Place of Purchase	Distance Traveled	Convert Distance Traveled from the previous Column into a Second Form

Free Map Tools:
https://www.freemaptools.com/how-far-is-it-between.htm

Follow-Up Questions

Who’s clothing traveled the farthest?

How much farther has Nate’s pants traveled than his T-Shirt?

Life in a Square

Interdisciplinary Connections

ECOLOGICAL LITERACY

The science of ecology studies the relations of organisms to one another and to their physical surroundings, and this physical space is referred to as an ecosystem.

However, the natural world, and thus ecosystems, are constantly changing due to many external factors causing an imbalance in the basic needs required of organisms to survive (e.g., water, food, shelter, etc.).

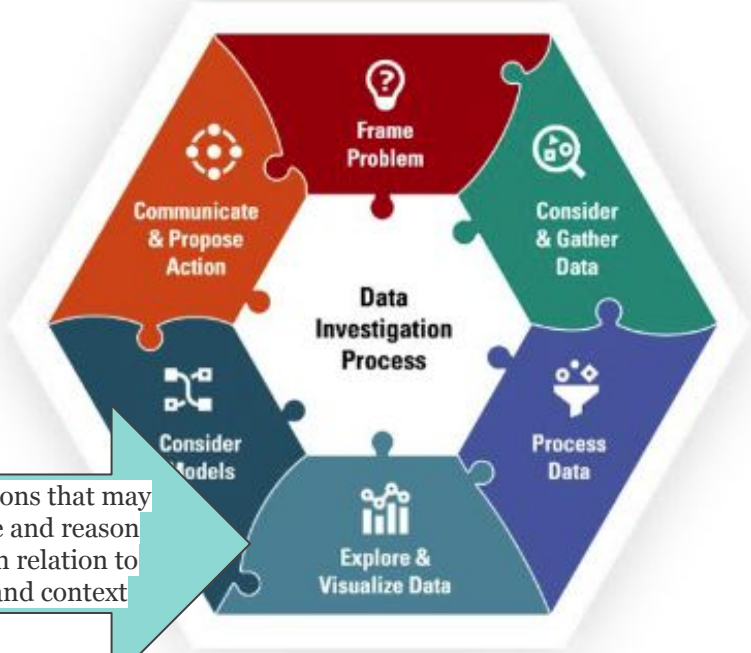
Through the study of a mini-ecosystem and comparisons across various mini-ecosystems, students can learn about what happens to an ecosystem when external factors cause change. **Data, and examining data for patterns over time,** is critical for meeting this goal and introducing students to the foundation of **ecological literacy.**

Life in a Square

What is an ecosystem and how can we determine if an ecosystem is healthy?

Objective: To identify *living versus non-living* components of an ecosystem

Thinking about Data Representation

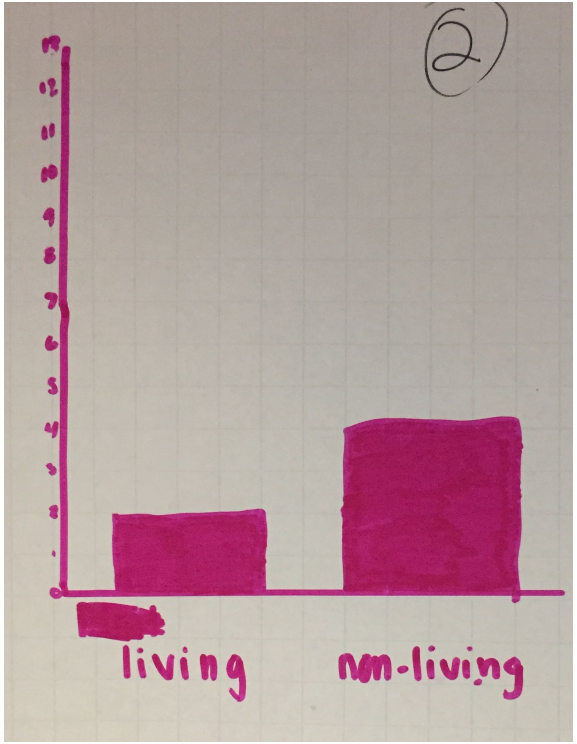


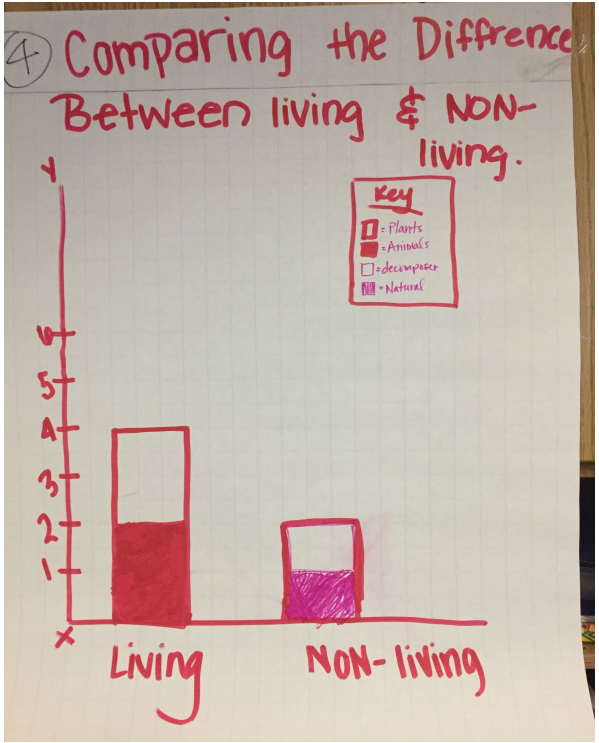
Create visualizations that may help you explore and reason about the data in relation to your question and context

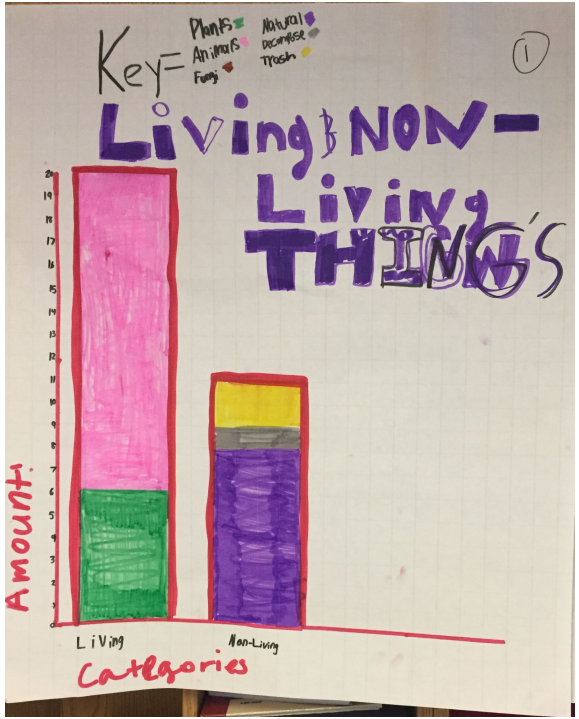
Data Organization

Name of item (or draw a picture if you don't know the name)	Description of item	Frequency of item in the square (or provide an estimated fraction of the area an item is covering of the square if there are lots of pieces of the item—too many to count)	Would you classify this item as living or non-living? Why?
animal home? 	- mound of mud - moist mud	2	non-living used as home natural
 flower dandelion	-dead	1	non-living -was living
moss 	moss -green -soft	moss 3-5 inches	moss -plant/fungus -living -needs water
Dirt 	-dirty -brown -full of animals/insects/etc.	All over (under the grass)	non living natural
 clover flower	-white with purple center	5-to-4	living plants

Data Representation







Thank You

Rick Hudson, rhudson@usi.edu

Dionne Cross Francis, dicross@unc.edu

Andrew Gatza, amgatza@bsu.edu